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Validation of integrated acceptance and sustainability assessment methodology

Dace Aizstrauta[a]*, Astrida Celmina[a], Egils Ginters[a], Riccardo Mazza[b]

[a]*Sociotechnical Systems Engineering Institute, Vidzeme University of Applied Sciences, Cesu Street 4, Valmiera, LV-4200, Latvia*
[b]*Direzione Technology, O.U. WIL IT Governance, Viadotto XXV Aprile 9,10015 Ivrea (TO), Italy*

Abstract

The elaboration and introduction of a new technology is a complex and expensive task, therefore it is necessary to assess the set of factors influencing the future of technology. The most important parameters of assessment are technology acceptance and sustainability. Different models exist, but most of them are static and do not offer possibilities for interactive and real time assessment and do not allow forecasting technology sustainability. The framework of FP7-ICT-2009-5 CHOREOS project No. 257178 elaborates a new two-step methodology, Integrated Acceptance and Sustainability Assessment Model (IASAM), for socio-technical assessment. This article describes the underlying model methodology and its validation process.

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Keywords: Technology acceptance and sustainability; IASAM; Validation; Skype.

1. Introduction

Different adoption/acceptance theories focus mainly on the exploitation stage and deal with prediction and modelling of user behaviour. These users make the decision to adopt a technology or reject it. But to invest in the development of new technologies, one has to be sure that the possibility of failure has been diminished in the development stage or during testing and maintenance, as different socio-technical factors influencing these stages

* Corresponding author.
E-mail address: dace.aizstrauta@va.lv

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might also lead to failure of the whole project. The Integrated Acceptance and Sustainability Assessment Model (IASAM), in turn, addresses the question of how to evaluate technology acceptance and sustainability at any chosen point in time of the technology life cycle and forecast the chances of technology to attract users and achieve the aims of its developers. What are the main elements and factors that influence the acceptance and sustainability of technology? IASAM suggests integrating the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et. al. [14] for acceptance evaluation with other socio-technical factors thus framing a united multi-level framework for technology assessment.

By introducing IASAM, the authors also propose the concept of technology sustainability for evaluation of a set of socio-technical factors that let the technology be developed, implemented, maintained properly (according to the needs of all stakeholders) and attract long-term users and create a positive output and/or outcome according to the purpose of the technology and initial intentions of its developers (financial, social, etc.).

2. Technology acceptance and sustainability evaluation

2.1. Previous studies

On a broader scale and taking into account technology-related research, there are several theories that partly reflect issues of acceptance, adoption and success, but none of them give a full understanding of the factors influencing acceptance and sustainability combined. Moreover, only a few theories analyse system sustainability even though this parameter is critically important for decisions about investments in technology development and exploitation.

Many studies focus on behavioural aspects of technology acceptance or adoption. There has been a lot of research on different factors that influence information technology acceptance – individual, organizational aspects, cultural, gender and professional differences. The most prominent model to be mentioned is the Technology Acceptance Model (TAM) [3]. It has been criticized for focusing on initial adoption and not on continuous use.[8] There are also other approaches, for example Expectation-Confirmation Theory (ECT) [3], which initially originated in the marketing industry, and Unified Theory of Acceptance and Use of Technology (UTAUT) that tries to consolidate eight approaches into one[14].

These theories question the factors behind the intentions and behaviour of users from a psychological perspective. Different variations of TAM, the UTAUT model, and ECT are just some to mention in the discussion of technology acceptance and adoption research.

The technology life-cycle approach concentrates on defining universal stages that can be applied to technology and innovation research. In comparison to acceptance research, this approach focuses on market forces and management decisions. In literature it is common to see the terms “industry life cycle”, “product life cycle” and “technology life cycle” used interchangeably, ambiguously and often inappropriately. Moreover the discourse is dominated by the product life cycle while the technology life cycle has largely been neglected[13]. Unit analysis for the technology life cycle is broader than a specific product or a process innovation, which applies to products sold in different markets[4]. Taylor&Taylor[13] point out that this is only the tip of the iceberg since there are also disconnects and inconsistencies pertaining to the various perspectives of the technology life cycle.

This approach does not answer all the questions regarding technology acceptance and sustainability as it rather concentrates on commercial/managerial problems and views technology as a separate item and does not analyse the differences of the technologies themselves.

Another theory that touches our field of interest is Diffusion of Innovations[9]. It looks at the spreading of innovative ideas within organizations or other social settings from a sociological perspective.

All these theories do relate to the field of this research, but at the same time they do not match our point of interest. Only by combining psychological and individual factors with both internal (connected with ICT development management and quality of technology) and external (connected with domain development) socio-technical factors, it is possible to have a full understanding of ICT development and exploitation.

2.2. System dynamics

System dynamics is one of several approaches of simulation. Simulation is recognized as suitable for studying different sociotechnical systems where engaging in a real system is not possible [10], for example, due to cost, risks, time restrictions, ethical factors etc.

The system dynamics approach provides an opportunity to simulate a continuous system with multiple feedback links and analyse quantitative and qualitative factors[2].

In addition, it is argued that a systemic perspective would enable stakeholders to make decisions consistent with their and the system's long-term interests[12].

The system dynamics approach allows describing technology development as a set of parallel processes. This set is characterized by:

- Socio-technical features of the system (dual nature: technical plus social and/or environmental factors);
- Development in a specific period of time;
- Involvement of multiple decision making entities, such as companies, institutions and individual consumers;
- A set of relevant internal and external socio-technical factors that impact the trends of individual change processes;
- The possibility to append or replace parameters[2].

2.3. IASAM methodology

IASAM consists of four groups of factors that have an impact on integrated technology acceptance and sustainability:

1) Management – successful management of every asset;
2) Quality of Technology – quality of the product;
3) Technology acceptance – customer/user acceptance of the new product;
4) Domain development and societal processes – the development of society demands more diverse technologies. After development that in turn changes society and also influences the demand for new technologies.

Acceptance is measured using UTAUT methodology and other factors are evaluated using a set of pre-defined criteria.

UTAUT is a definitive model that synthesizes what is known and provides a foundation to guide future research in this area. By encompassing the combined explanatory power of the individual models and key moderating influences, UTAUT advances cumulative theory while retaining a parsimonious structure[14].

By using system dynamics the model allows its users to monitor the variation of the IASAM index over time[1].

A graphical representation of the model can be seen in Fig. 1.

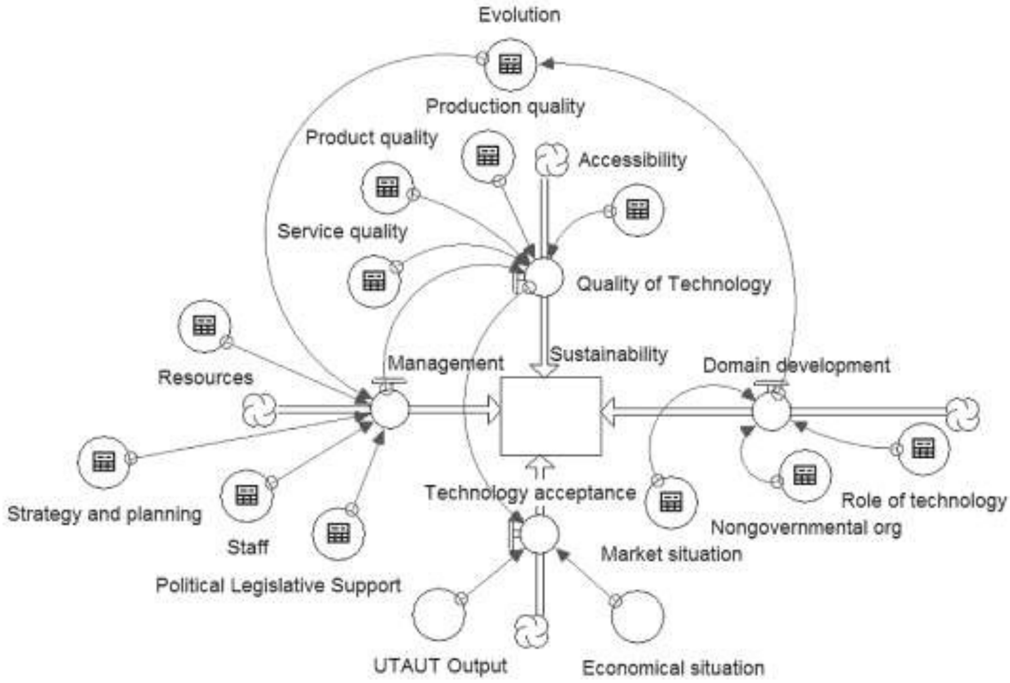

Fig. 1. IASAM model in Stella notation.

The use of the IASAM approach is not limited to any system dynamics tool. STELLA[11], being a commercial product, offers certain advantages but, for example, the use of open-source software Insight Maker[6] broadens the eventual target audience of IASAM methodology users.

Each IASAM flow consists of several criteria. Each criterion is evaluated with the help of a specially formulated criteria description/statement. (Altogether the model provides 49 statements). The respondent evaluates each description. The evaluation step and calculation are described further.

First, the statement provided for each criterion is evaluated on the 7 point Likert scale. If it is not possible to assess any criteria at the time of the current evaluation (for example, the evaluator does not know the answer because the technical specification is not yet ready), the criteria should be marked with “NA”.

The result gives a numerical value for the integrated technology sustainability index (IASAM index) consistent with the IASAM assessment framework. The integrated technology sustainability index evaluates the conformity to IASAM framework criteria. It is calculated as the sum of all values from the questionnaire and divided by the maximum possible value of questions answered.

$$index = \frac{\sum(\xrightarrow[j=1,38]{} A_j + \xrightarrow[i=1,49]{} B_i)}{(N-C)*7} \quad (1)$$

, where
A – UTAUT survey response values;
B – IASAM survey response values;

N – Total number of questions;
C – Number of questions marked with “N/A”.

This result is then combined with UTAUT questionnaire results. UTAUT is aimed at potential users and gives information about technology acceptance. The evaluation is made according to the methodology described in Venkatesh et. al. [14] and then integrated into the IASAM model. For a better understanding of UTAUT integration within IASAM see Fig. 2.

The UTAUT survey is carried out separately and the results are used in two ways. First, the separate analysis of UTAUT survey results forms a comprehensive understanding of potential user acceptance. Secondly, the integration of certain answers into IASAM results adds the acceptance perspective to the model.

The integration means that the median answer of UTAUT questions (for each question from 1-10) is calculated and then these medians are added to IASAM calculations. This also increases the total number of questions that are viewed in IASAM.

Afterwards, the procedure calculates result consistency. This value is called IASAM credibility and looks at the number of questions left without value (those marked with NA) and decreases the “internal credibility” of the value obtained in the previous step. The more questions are marked with NA, the less consistent is the result. This does not mean that the technology sustainability index is lower.

$$E = \frac{C}{N} \qquad (2)$$

, where
E – Credibility;
N – Total number of questions;
C – Number of questions marked with “N/A”.

Thus the measurement gives two results – the sustainability index and the credibility for the calculated index.

An important step in the development process of modelling is model verification and validation, and IASAM cannot be an exception.

3. IASAM methodology validation

Validation is the process of determining the degree to which a model is an accurate representation of reality[10].

The IASAM validation process can be seen in Fig. 3. First, the validation method and case-study selection methods were defined.

The chosen method for validation implies testing the IASAM model results against a real existing technology that meets the following requirements:

- It is innovative;
- Information on its development and exploitation is available on the Internet;
- It has succeeded in the market (it has survived for at least 5 years, it has been able to attach new users, has been developing since its release, etc.)
- It is widely known and popular worldwide.

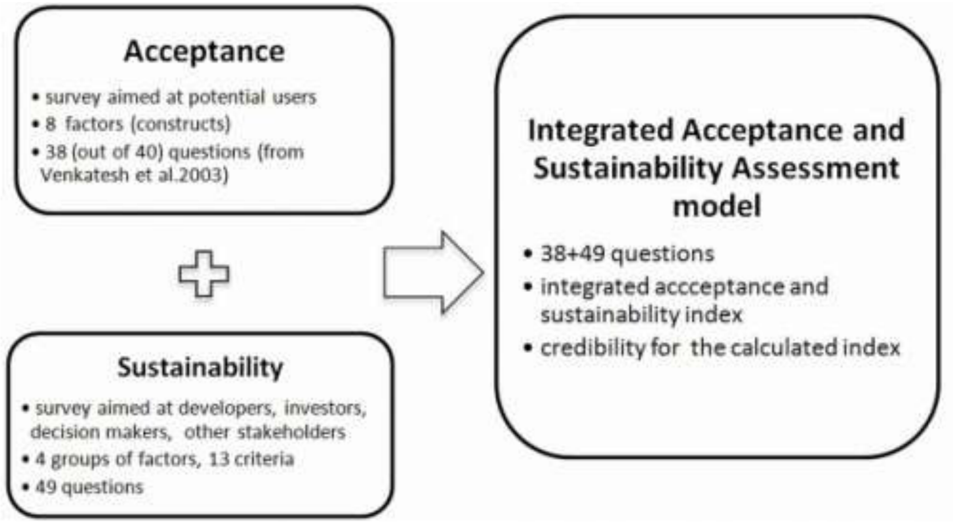

Fig. 2. IASAM and UTAUT integration.

According to these requirements, the case-study for the validation will be the development and exploitation of Skype as one of the success stories.

Further evaluation consists of these main steps:

- Choosing keywords for model criteria.
- Information search within the World Wide Web according to keywords.
- Evaluation of the returned search results.
- Criteria scoring.

Taking into account that Skype has millions of users worldwide (in May 2013 Skype passed the phenomenal number of 59 million concurrent people online at peak daytime[7]) and the dynamics of new users, the UTAUT model output is evaluated with the maximum possible score (i.e. 266).

The validation process is documented in a set of tables – one for each model criterion. (The full package of tables can be obtained in FP7-ICT-2009-5 CHOREOS project No. 257178 “Large Scale Choreographies for the Future Internet (IP)” deliverable D10.4). The concentrated version of the validation process, namely the scores of the criteria together with the maximum obtainable score, can be found in the Table 1.

The Table 1 shows that every criterion has obtained an evaluation close to the possible maximum. That has resulted in a high IASAM index for Skype - 0.91. According to the methodology, IASAM criteria have received high evaluations. Important issues regarding the management, quality of technology, acceptance and domain development are fully performed or deliberated.

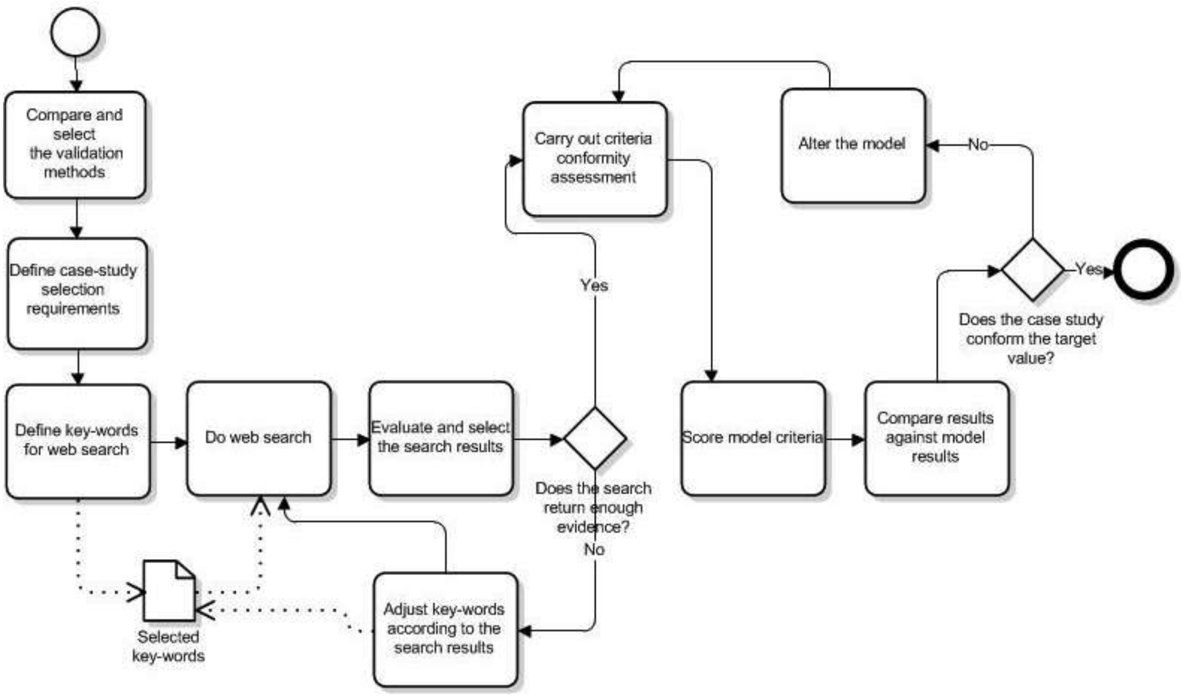

Fig. 3. IASAM validation process.

The technology greatly satisfies the defined IASAM criteria. The technology proves to be accepted among target group members and sustainable in terms of technology existence, financial gain and other targets set by its developers.

Table 1. Skype evaluation per IASAM criteria and the final IASAM index score.

IASAM Criteria	Criteria evaluation for Skype/ max possible evaluation within criteria	IASAM Criteria	Criteria evaluation for Skype/ max possible evaluation within criteria
Staff	14/14	Resources	15/21
Strategic management	46/49	Product quality	30/35
Production quality	38/49	Service quality	28/28
Politico/legal support	20/28	Accessibility	18/21
Evolution	24/28	Market situation	18/21
NGOs/informal groups	11/14	Role of technology	13/14
Economical situation	7/7	UTAUT model output (37 questions)	266/266
Final IASAM index score	**0.91**		
Credibility	**0.98**		

4. Conclusions

Previous research focuses on psychological or socio-economic aspects of technology acceptance separately, specifically on the success of ICTE projects, management systems, or diffusion on innovations as a whole. The authors of this paper present a new approach for the evaluation of technologies that combines socio-economic aspects and socio-technical characteristics of technology development and exploitation. It is built on a notion that only by combining psychological and individual factors with both internal and external socio-technical factors is able to have a full understanding of the ICT development and exploitation.

This paper focuses on the validation of this approach. The validation method is described and validation is carried out for Skype. Skype case analysis has helped to validate the IASAM methodology, as this score indicates that important issues regarding management, quality of technology, acceptance and domain development are fully performed or deliberative.

Thus the IASAM methodology can be used for technology evaluation and decision-making if the criteria and statements are defined appropriately. Nevertheless, research is needed to define whether this methodology can be adapted to technologies in a broader sense i.e. beyond ICTEs.

This kind of evaluation tool can be useful to idea owners, technology developers, investors, government officials and researchers for estimating the prospects of new technology.

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